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ABSTRACT

This paper summarizes an experiment conducted to examine the counting performance of 7- and 8-year-olds. Analysis of variance was computed on counting errors produced when enumerating a set of squares on a computer screen. The factors included in the analysis were age, gender, array size, error type, proximity, and error form. The primary conclusion of this analysis is that the impact of including error type does not lead to theoretically important changes in results compared to the omission of this factor. It is also noted that with a skewed data set, where the errors were too infrequent to avoid floor effects, spurious results are possible. Therefore, any effects which are of particular interest should be replicated before particular weight is placed upon them. The bulk of the paper consists of statistical tables related to the experiment. (MDM)

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Analysis of types of errors made by children in counting objects: A quantitative breakdown of data.

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Towse & Hitch (1995) describe a study of counting performance among a group of 7 and 8 year-old children (Experiment 1 in their paper). The performance demands characterising counting behavior motivated the experimental investigation. A full analysis of errors with all experimental factors and error types was not described in detail, however, because the assumptions underlying a large scale analysis of variance on limited data were severely stretched. That is, there were a large number of empty cells in the data matrix, reducing the reliability of the findings. Furthermore, the inclusion of error categories introduced some complicated effects which were not directly interpretable in theoretical terms. However, this short report quantifies the effects which were obtained.

Analysis of variance was computed on counting errors produced when enumerating a set of squares on a computer screen. The factors included in the analysis were Age (labelled here 'Younger' and 'Older'), Gender

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('Male' and 'Female'), Size (array numerosity was 'Small', 'Medium', and 'Large), Type (i.e. the object arrangement; labelled here as 'Horiz'[ontal], 'Vert[ical], and 'Random'), Proximity ('High' and 'Low'), and Form (errors were either 'O-count' [overcounts] or 'U-count' [undercounts]. A summary table of effects is presented below, followed by a list of all mean tables for significant effects and interactions, with α=0.05.

The primary conclusion to be drawn from this analysis is that the impact of including error type does not lead to theoretically important changes in the results, compared to the omission of this factor. New effects do emerge, but these are not particularly coherent from an interpretive perspective. It is also worth bearing in mind that, with a skewed data set such as this (where errors are too infrequent to avoid floor effects), spurious results are possible. Therefore, any effects which are of particular interest in some other context should be replicated before too much weight is placed upon them. For further methodological details and discussion, refer to Towse & Hitch (1995).

References

Towse, J. N., & Hitch, G. J. (1995). Performance demands in the selection of objects for counting. Journal of Experimental Child Psychology. In Press.

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Age	1	1.276	1.276	.643	.4283
Gender	1	2.831	2.831	1.427	.2407
Age * Gender	1	.746	.746	.376	.5439
Subject(Group)	33	65.451	1.983		
Size	2	16.745	8.373	17.172	.0001
Size * Age	2	1.893	.947	1.941	.1516
Size * Gender	2	1.036	.518	1.062	.3514
Size * Age * Gender	2	.047	.023	.048	.9533
Size * Subject(Group)	66	32.180	.488		
Type	2	1.817	.908	3.043	.0544
Type * Age	2	4.064	2.032	6.809	.0020
Type * Gender	2	3.264	1.632	5.468	.0063
Type * Age * Gender	2	.636	.318	1.066	.3503
Type * Subject(Group)	66	19.698	.298		
Proximity	1	1.861	1.861	9.062	.0050
Proximity * Age	1	.271	.271	1.319	.2590
Proximity * Gender	1	.529	.529	2.576	.1181
Proximity * Age * Gender	1	.007	.007	.033	.8573
Proximity * Subject(Group)	33	6.776	.205		
Form	1	5.363	5.363	6.676	.0144
Form * Age	1	1.643	1.643	2.046	.1620
Form * Gender	1	.043	.043	.053	.8190
Form * Age * Gender	1	.027	.027	.034	.8547
Form * Subject(Group)	33	26.512	.803		
Size * Type	4	1.576	.394	2.020	.0953
Size * Type * Age	4	.552	.138	.708	.5880
Size * Type * Gender	4	1.297	.324	1.663	.1625
Size * Type * Age * Gender	4	.757	.189	.970	.4260
Size * Type * Subject(Group)	132	25.750	.195		
Size * Proximity	2	1.727	.863	5.478	.0063
Size * Proximity * Age	2	1.118	.559	3.545	.0345
Size * Proximity * Gender	2	.922	.461	2.926	.0606
Size * Proximity * Age * Gender	2	.281	.140	.890	.4155
Size * Proximity * Subject(Group)	66	10.404	.158		
Type * Proximity	2	.289	.144	.801	.4532
Type * Proximity * Age	2	.043	.022	.120	.8875
Type * Proximity * Gender	2	.069	.035	.192	.8258
Type * Proximity * Age * Gender	2	.442	.221	1.228	.2994
Type * Proximity * Subject(Group)	66	11.888	.180		
Size * Form	2	1.606	.803	1.727	.1857
Size * Form * Age	2	1.376	.688	1.480	.2351
Size * Form * Gender	2	5.283	2.642	5.682	.0053
Size * Form * Age * Gender	2	.379	.190	.408	.6667
Size * Form * Subject(Group)	66	30.684	.465		
Type * Form	2	5.018	2.509	7.248	.0014
Type * Form * Age	2	.472	.236	.681	.5094
Type * Form * Gender	2	.043	.021	.061	.9405
Type * Form * Age * Gender	2	.946	.473	1.367	.2620
Type * Form * Subject(Group)	66	22.845	.346		
Proximity * Form	1	.600	.600	2.478	.1250
Proximity * Form * Age	1	.378	.378	1.563	.2201
Proximity * Form * Gender	1	.241	.241	.996	.3256
Proximity * Form * Age * Gender	1	.009	.009	.036	.8498
Proximity * Form * Subject(Group)	33	7.988	.242		
Size * Type * Proximity	4	.255	.064	.308	.8721
Size * Type * Proximity * Age	4	.439	.110	.531	.7132
Size * Type * Proximity * Gender	4	.108	.027	.131	.9707
Size * Type * Proximity * Age * Gender	4	.104	.026	.126	.9727
Size * Type * Proximity * Subject(Group)	132	27.275	.207		
Size * Type * Form	4	.837	.209	.815	.5175
Size * Type * Form * Age	4	.395	.099	.385	.8189
Size * Type * Form * Gender	4	1.976	.494	1.925	.1100
Size * Type * Form * Age * Gender	4	.728	.182	.709	.5869
Size * Type * Form * Subject(Group)	132	33.881	.257		
Size * Proximity * Form	2	.190	.095	.809	.4497
Size * Proximity * Form * Age	2	1.036	.518	4.410	.0159
Size * Proximity * Form * Gender	2	.982	.491	4.180	.0195
Size * Proximity * Form * Age * Gender	2	.572	.286	2.436	.0953
Size * Proximity * Form * Subject(Group)	66	7.749	.117		
Type * Proximity * Form	2	.220	.110	.553	.5778
Type * Proximity * Form * Age	2	.025	.013	.063	.9388
Type * Proximity * Form * Gender	2	.012	.006	.030	.9705
Type * Proximity * Form * Age * Gender	2	.112	.056	.281	.7561
Type * Proximity * Form * Subject(Group)	66	13.108	.199		
Size * Type * Proximity * Form	4	1.055	.264	.956	.4339
Size * Type * Proximity * Form * Age	4	.671	.168	.608	.6574
Size * Type * Proximity * Form * Gender	4	1.033	.258	.936	.4453
Size * Type * Proximity * Form * Age * Gender	4	.542	.136	.492	.7420
Size * Type * Proximity * Form * Subject(Group)	132	36.416	.276		

Dependent: Error frequencies

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Table of Epsilon Factors for df Adjustment
Dependent: Error frequencies

	G-G Epsilon	H-F Epsilon
Size	.848	.970
Type	.927	1.070
Proximity	1.000	1.094
Form	1.000	1.094
Size * Type	.848	1.043
Size * Proximity	.875	1.004
Type * Proximity	.834	.953
Size * Form	.656	.734
Type * Form	.956	1.106
Proximity * Form	1.000	1.094
Size * Type * Proximity	.806	.984
Size * Type * Form	.767	.932
Size * Proximity * Form	.941	1.087
Type * Proximity * Form	.947	1.094
Size * Type * Proximity * Form	.754	.914

NOTE: Probabilities are not corrected for values of epsilon greater than 1.

Means Table
Effect: Size
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Small	444	.115	.444	.021
Medium	444	.223	.548	.026
Large	444	.401	.706	.033

Means Table
Effect: Type * Age
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Horiz, 7 years	228	.158	.498	.033
Horiz, 8 years	216	.241	.568	.039
Vert, 7 years	228	.171	.480	.032
Vert, 8 years	216	.380	.737	.050
Random, 7 years	228	.294	.634	.042
Random, 8 years	216	.241	.552	.038

Means Table
Effect: Type * Gender
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Horiz, Male	180	.211	.539	.040
Horiz, Female	264	.189	.532	.033
Vert, Male	180	.300	.624	.047
Vert, Female	264	.254	.629	.039
Random, Male	180	.406	.707	.053
Random, Female	264	.174	.485	.030

Means Table
Effect: Proximity
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
High	666	.281	.596	.023
Low	666	.212	.577	.022

Means Table
Effect: Form
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
O-count	666	.311	.666	.026
U-count	666	.182	.489	.019

Means Table
Effect: Size * Proximity
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Small, High	222	.104	.396	.027
Small, Low	222	.126	.487	.033
Medium, High	222	.279	.597	.040
Medium, Low	222	.167	.489	.033
Large, High	222	.459	.703	.047
Large, Low	222	.342	.705	.047

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Means Table
Effect: Size * Proximity * Age
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Small, High, 7 years	114	.114	.436	.041
Small, High, 8 years	108	.093	.350	.034
Small, Low, 7 years	114	.132	.572	.054
Small, Low, 8 years	108	.120	.380	.037
Medium, High, 7 years	114	.193	.477	.045
Medium, High, 8 years	108	.370	.692	.067
Medium, Low, 7 years	114	.105	.336	.031
Medium, Low, 8 years	108	.231	.605	.058
Large, High, 7 years	114	.456	.730	.068
Large, High, 8 years	108	.463	.676	.065
Large, Low, 7 years	114	.246	.558	.052
Large, Low, 8 years	108	.444	.824	.079

Means Table
Effect: Size * Form * Gender
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Small, O-count, Male	90	.356	.812	.086
Small, O-count, Female	132	.083	.304	.026
Small, U-count, Male	90	.078	.308	.032
Small, U-count, Female	132	.008	.087	.008
Medium, O-count, Male	90	.378	.680	.072
Medium, O-count, Female	132	.258	.638	.055
Medium, U-count, Male	90	.133	.342	.036
Medium, U-count, Female	132	.144	.430	.037
Large, O-count, Male	90	.367	.589	.062
Large, O-count, Female	132	.477	.815	.071
Large, U-count, Male	90	.522	.768	.081
Large, U-count, Female	132	.265	.591	.051

Means Table
Effect: Type * Form
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Horiz, O-count	222	.275	.660	.044
Horiz, U-count	222	.122	.354	.024
Vert, O-count	222	.405	.748	.050
Vert, U-count	222	.140	.439	.029
Random, O-count	222	.252	.570	.038
Random, U-count	222	.284	.621	.042

Means Table
Effect: Size * Proximity * Form * Age
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Small, High, O-count, 7 years	57	.175	.539	.071
Small, High, O-count, 8 years	54	.148	.452	.061
Small, High, U-count, 7 years	57	.053	.294	.039
Small, High, U-count, 8 years	54	.037	.191	.026
Small, Low, O-count, 7 years	57	.228	.780	.103
Small, Low, O-count, 8 years	54	.222	.502	.068
Small, Low, U-count, 7 years	57	.035	.186	.025
Small, Low, U-count, 8 years	54	.019	.136	.019
Medium, High, O-count, 7 years	57	.193	.441	.058
Medium, High, O-count, 8 years	54	.519	.841	.114
Medium, High, U-count, 7 years	57	.193	.515	.068
Medium, High, U-count, 8 years	54	.222	.462	.063
Medium, Low, O-count, 7 years	57	.140	.398	.053
Medium, Low, O-count, 8 years	54	.389	.787	.107
Medium, Low, U-count, 7 years	57	.070	.258	.034
Medium, Low, U-count, 8 years	54	.074	.264	.036
Large, High, O-count, 7 years	57	.456	.657	.087
Large, High, O-count, 8 years	54	.444	.664	.090
Large, High, U-count, 7 years	57	.456	.803	.106
Large, High, U-count, 8 years	54	.481	.693	.094
Large, Low, O-count, 7 years	57	.228	.535	.071
Large, Low, O-count, 8 years	54	.611	.979	.133
Large, Low, U-count, 7 years	57	.263	.583	.077
Large, Low, U-count, 8 years	54	.278	.596	.081

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Means Table
Effect: Size * Proximity * Form * Gender
Dependent: Error frequencies

	Count	Mean	Std. Dev.	Std. Error
Small, High, O-count, Male	45	.289	.695	.104
Small, High, O-count, Female	66	.076	.267	.033
Small, High, U-count, Male	45	.111	.383	.057
Small, High, U-count, Female	66	0.000	0.000	0.000
Small, Low, O-count, Male	45	.422	.917	.137
Small, Low, O-count, Female	66	.091	.339	.042
Small, Low, U-count, Male	45	.044	.208	.031
Small, Low, U-count, Female	66	.015	.123	.015
Medium, High, O-count, Male	45	.467	.726	.108
Medium, High, O-count, Female	66	.273	.646	.079
Medium, High, U-count, Male	45	.178	.387	.058
Medium, High, U-count, Female	66	.227	.549	.068
Medium, Low, O-count, Male	45	.289	.626	.093
Medium, Low, O-count, Female	66	.242	.634	.078
Medium, Low, U-count, Male	45	.089	.288	.043
Medium, Low, U-count, Female	66	.061	.240	.030
Large, High, O-count, Male	45	.489	.626	.093
Large, High, O-count, Female	66	.424	.681	.084
Large, High, U-count, Male	45	.644	.830	.124
Large, High, U-count, Female	66	.348	.668	.082
Large, Low, O-count, Male	45	.244	.529	.079
Large, Low, O-count, Female	66	.530	.932	.115
Large, Low, U-count, Male	45	.400	.688	.102
Large, Low, U-count, Female	66	.182	.493	.061